OPERATIVE TREATMENT OF ANEURISMS OF THE THIRD PORTION OF THE SUBCLAVIAN ARTERY.[1]

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HISTORY.

THE aim of this effort is to fix the present state of the science and art of surgery on the most important subject of the operative treatment of aneurisms of the third portion of the subclavian artery, and to endeavor to outline rules of treatment for the future.

Considering the relative frequency of the disease and the deadly results of so many bloody operations performed by famed and bold surgeons upon no less brave and courageous patients, there is no subject worthier of the deepest thoughts of the most surgically gifted, even of the envied ones blessed with the divine spark called genius.

As far as we could ascertain by our own researches and through circular postal cards sent to all the surgeons of note of America and of Europe, this is the first time that this subject is thoroughly studied in all its bearings as a distinct disease. It is based on the study of 115 operated cases herein reported, of which thirty-one are traumatic, eighty-one idiopathic, and three recurrent. Never before have the traumatic aneurisms of the third portion been described at all, although replete with most poignant interest. There exists no description of recurrent aneurism, nor of the peculiarities of those aneurisms on the left side, and some of these peculiarities are of prime importance.

Arterio-venous aneurisms are barely mentioned.

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These are the first and most important clinical distinctions, but there are others, also clinical, to be mentioned below, quite as important to make at the very beginning, if we wish to understand each other and to prevent one from thinking of one form of the disease when a speaker or writer is thinking of another. This confusion is made all along in books and in discussions in societies, and is the cause of a great deal of useless talk and of a great waste of valuable time. All text-books speak of this subject, but more or less briefly and more or less confusedly.

We are especially indebted to the elegant and able pen of the accomplished late T. T. Sabine[1] for a masterly handling of a certain part of the subject; to the remarkable statistics of Alfred Poland,[2] of Koch,[3] of Crisp,[4] of Norris.[5] Also to the energetic and painstaking Wyeth,[6] of New York; to the achievements of the world-renowned Senn,[7] of Ballance and Edmunds,[8] and, finally, to the regretted Professor Leon Lefort,[9] of Paris, but recently deceased. We are under much obligation to the National Bureau of Medical Bibliography, of Washington, D. C.,[10] for valuable researches in the Library of the Surgeon-General's Office.

There are no less than ninety-five names connected with the evolution of the history of the operative treatment of aneurisms of this third portion, and such a galaxy of mighty brains!

GENERAL CONSIDERATIONS.

Frequency.—Aneurisms of the subclavian artery are nearly as frequent as those of the carotid. They are more frequent on the third portion (Poland).

They are more frequent on the right side, 66 per cent., than on the left; out of 120 cases, 85 were on the right side; 2 cases included both sides (Poland).

The spontaneous or idiopathic are six times more common (Poland).

Important Rule.—A most important rule is that no operation should be attempted until all the non-operative measures have been tried.

Out of 22 cases, 4 cured spontaneously, 18 per cent.; 18 died, 81 per cent. (Poland).

Out of 14 cases treated by Valsalva's method more or less modified, 7 recovered, 50 per cent.; 2 were lost sight of during the process of cure, and 5 died, 35 per cent.[11]

Again, out of 5 cases treated by direct pressure without operative procedures, 4 were cured and 1 died, 20 per cent.[12]

Lastly, out of 6 cases treated by massage and kneading, 3 were cured, 50 per cent.; and 3 died, 50 per cent. (Wyeth).

Out of 35 cases where no operation was resorted to, 11 recovered, 31 per cent.; 23 died, 65 per cent.; and 1 was improved.[13]

The non-operative measures to be tried before operating are judicious venesection, prolonged, persistent, and perfect rest in decubitus, low diet, heart depressants carefully used, iodide of potassium in increasing doses, compression on the tumor, iced applications, kneading.[14]

Direct pressure may be practised by means of any substance that will press equally upon the outer surfaces of the tumor, applied gradually in order to accustom the patient and the tumor to its presence.[15]

Dr. Wyeth recommends a soft rubber ball placed upon the tumor and gradually brought to press upon it by means of a bandage around the neck and beneath the axilla.[16]

Traumatic aneurisms also may be cured by digital compression of the artery.

A case is reported by Bergmann of a man of thirty who received a punctured wound in the left subclavian artery; profuse hæmorrhage with extensive infiltration of blood in anterior and lateral walls of thorax; nine weeks later, after external wound had healed and infiltration had disappeared, patient presented under the left pectoral muscle a large pulsating tumor, which, through pressure on the brachial nerves, was causing much disturbance of sensibility; the aneurism was ultimately cured by digital compression above the clavicle.[17]

The following is another case reported by Warren-Stone:

Traumatic aneurism of left subclavian; distal pressure applied to third portion of the artery for thirty-nine hours; tumor diminished one-half in size; was much harder and its pulsations feebler; it continued to diminish, and in nine months all pulsations had disappeared; two years later the tumor reduced to a pulseless, barely recognizable stump.[18] The pressure on the sac itself would not be so likely to succeed in traumatic aneurisms.

The introduction of wire, horse-hair, galvano-puncture, and injections in the cavity of the sac are not to be practised.[19]

DIVISIONS AND SUBDIVISIONS, OR CLINICAL FORMS AND VARIETIES.

The first of the clinical distinctions is to treat separately of the aneurisms on the right side and of those on the left side.

Aneurisms of the Third Portion of the Right Subclavian Artery.—On the right side we must study the traumatic aneurisms and the idiopathic; then the recurrent, which may be traumatic or idiopathic. This division of aneurisms into traumatic and idiopathic commends itself here especially.

The greatest point of difference besides the cause is that in the former it is only a coincidence, when the arterial walls are diseased and the general condition of the patient not good; whereas in the latter a more or less advanced diseased state of the walls is constantly present and the general health of the subject is more or less impaired so as to bring about such a state of the arterial tissues. This sufficiently accounts for the marked discrepancies in the results of operations in the two kinds of aneurisms.

Traumatic Aneurisms of the Right Side.—We succeeded in collecting fourteen cases of traumatic aneurisms of the right side under the names of Colles, Bullen, Arendt, Wattman, Auvert, Roux, Pitha, Cuveiller, Langenbeck (three cases), Thiersch, Lewtas, and Miles.

We did not include any case due to so-called "strains," or catching at something or other in a fall, etc., but we have included those cases where an aneurism developed after a blow direct on the region where the tumor appeared, and also those following dislocations of the shoulder and due either to the injury or to the reduction by the surgeon.

I.—1811. Colles. Right traumatic aneurism; ligation of first portion. Man aged thirty-three years. Patient thinks he repeatedly hurt himself by endeavoring to push with his shoulder a loaded car, the wheels of which had sunk deep into the mud; about a week after this exertion he began to complain and felt a tumor the size of a cherry; on account of subclavian being diseased, the ligature was placed within one-half inch of innominate; pleura wounded; ligature not tightened immediately; on fourth day, hæmorrhage and death; ulceration of subclavian near ligature.[20]

II.—1823. Bullen. Right traumatic subclavio-axillary aneurism; tar-barrel fell on shoulder; ligature of second portion; hæmorrhage; cure. Right pulse, which was scarcely perceptible before ligature, was very distinct after.[21a]

III.—1827. Arendt. Man aged thirty-six years. Blow on shoulder, which swelled immediately, but subsided upon application of cold; six weeks before the operation tumor had reappeared and increased rapidly in size; ligature of innominate half an inch below the bifurcation; pyæmia (?); exhaustion; death on eighth day; innominate closed, ligature not being separated.[21b]

IV.—1843. Wattman. Right (or left) traumatic subclavian aneurism, due to shot-wound; ligature of third portion; hæmorrhage; death.[22]

V.—1848. Auvert. Right traumatic subclavian aneurism following reduction of dislocation of shoulder; ligature of first portion; hæmorrhage; death; proximal end closed by clot; distal end open.[23]

VI.—1855. Roux. Right traumatic aneurism from punctured wound of axilla and shoulder; ligation of second portion; on third, fourth, or fifth day, hæmorrhages; death.[24]

VII.—1856. Pitha. Right traumatic diffuse aneurism, due to rupture of circumflex artery in attempting to reduce a dislocation of the shoulder; tumor size of a man's head; ligature between the scalenes; pneumonia; death.[25]

VIII.—1859. Cuveiller. Large right traumatic aneurism of third portion of subclavian from bayonet-wound; ligation of the first portion of the subclavian and also of the common carotid; on fifth day, recurrent hæmorrhage; on ninth day, death from exhaustion; distal end of subclavian opened, but proximal end closed; the ligature had been applied close to the origin of the collateral branches; common carotid closed.[26]

IX.—1862. Langenbeck, No. 1. Right (?) traumatic diffuse aneurism due to stab-wound necessitating ligature of subclavian between the scalenes; pyæmia; death on ninth day; thrombus formed on either side of artery.[27]

X.—1882. Thiersch, of Leipsic. Right traumatic subclavian aneurism. Man, aged twenty-eight years; punctured wound of neck; profuse hæmorrhage, which stopped spontaneously next day; large tumor in supra- and infraclavicular regions presenting all symptoms of aneurism; return of hæmorrhage; ligature of subclavian in third portion; incision of sac and clots turned out; tried to ligate the ends of the vessel, but could not find them; pyæmia and, on the fifteenth day, death.[28]

XI.—1884. Langenbeck, No. 2. Right (?) traumatic aneurism, from bullet-wound injuring the subclavian artery and bra̍chial plexus; there was the formation of a slowly increasing hæmatoma; repeated slight bleeding from it and subsequent anæmia, incision of the sac, turning out of the clots and ligation of both ends; cured.[29]

XII.—1884. Langenbeck, No. 3. Right (?) traumatic aneurism on a young lad who had a penetrating wound from a knife, causing considerable effusion of blood under the soft parts of the anterior wall of the thorax; pyæmia; death.[30]

XIII.—1889. Lewtas. Man, aged thirty years; explosion of shot-gun; piece of breech penetrated the neck above right clavicle; wound about one inch in length in front of attachment of sterno-mastoid muscle; hæmorrhage from wound for three days; swelling as large as a fœtal head at term in posterior triangle of neck; swelling is hard, but is not pulsating; wound enlarged, finger introduced, removal of a piece of steel weighing three drachms; alarming hæmorrhage upon withdrawal of the finger; reintroduction of the finger, and detection of a wound in the subclavian artery behind the scalenus anticus; attempted to seize the vessel with Spencer Wells forceps guided by the touch, but failed; ligature of the common carotid with catgut, leaving ends of ligature long, so that by drawing upon them one might be guided to the innominate; ligature of the innominate with catgut, just below its bifurcation; incision of sac and removal of clots; drainage-tube; recovery; left hospital on forty-third day carrying his right arm in a sling; no pulsation in radial artery; slight pulsation in brachial. The author remarks candidly that had he known at the time how unsuccessful previous operations of that sort had been, he does not think that he would have undertaken it.[31a]

XIV.—1893. Miles. Right traumatic aneurism, due to gun-shot wound of the middle of the third portion; there was much swelling in the supraclavicular region; a provisional loop ligature was placed on the first portion of the subclavian,—that is, a silk loop was passed around the artery, and while the fingers of one hand pulled on the loop to raise the artery the index-finger of the other hand pressed on the artery against the loop; the axillary was compressed by an assistant; the tumor in the supraclavicular region was incised and the clots turned out; the proximal end of the wounded artery was first ligated, then the distal end; the provisional ligature was then removed; the wound granulated and the patient recovered without any peculiar symptoms.[31b]

Peculiar case.—1890. Twyman. The following case of Twyman, of "pseudo-aneurism of the third portion," is most instructive as simulating an aneurism of the third portion itself and showing the difficulty of diagnosis in some cases.

Girl, aged eighteen years; fell from a horse against a stump; fracture of right clavicle at the junction of the outer and middle third; formation of an aneurism, supposed to be due to the penetration of the artery by a sharp point of bone; when first seen the swelling was about the size of half of a walnut, just over the artery; at the time of admission in the hospital the swelling extended from the sterno-clavicular articulation to the top of the inner fragment (three and a half inches), partly overlapping the inner fragment and extending also to a point one and a half inch from the top of the acromion; upward the highest point reached was at the back of the fourth cervical vertebra, at a point half-way between the spine and the trachea; inward the tumor reached sufficiently far to press on the carotid vessels; operation thirty-one days after the accident; the innominate was easily ligated, being pulled up about three-quarters of an inch by the tumor; the carotid was ligated an inch above the bifurcation; eighteen hours after operation, comatose condition and death; autopsy shows wound of first part of subclavian at about one-sixth of an inch external—*i.e.*, distal—to the origin of the thyroid axis and vertebral; phrenic nerve involved in the greatly condensed and thickened fibrous tissue forming the sac.

Thus the symptoms were mostly those of an aneurism of the third portion, especially remembering the site of the fracture and the site of the first appearance of the tumor. The excessive swelling is evidently the reason that induced the operator to ligate the innominate; and the common carotid was ligated also to provide against secondary hæmorrhage. But the case was one of aneurism of the first portion near the second portion. The treatment happened to be the proper one.

If a provisional loop ligature had been applied here, the operator would have been much perplexed, after incising and removing the clots, at finding the third portion unwounded. Out of twenty-two accepted cases of such ligation as was done by Twyman, cerebral symptoms have occurred in three. It is little doubtful that pressure on the phrenic nerve assisted materially the fatal accident.[32]

FOURTEEN TRAUMATIC ANEURISMS OF THE

No.	Year.	Name of Surgeon.	Cause and Duration of Aneurism.	Operation.
I.	1811	Colles.	Contusion of supraclavicular region; subclavian aneurism.	Ligation of first portion.
II.	1823	Bullen.	Tar-barrel fell on shoulder; subclavio-axillary aneurism.	Ligation of second portion.
III.	1827	Arendt.	Blow on shoulder; subclavian aneurism.	Ligation of innominate.
IV.	1843	Wattman.	Shot-wound; subclavio-axillary aneurism.	Ligation of third portion.
V.	1848	Auvert.	Followed reduction of dislocation of shoulder; subclavian aneurism.	Ligation of first portion.
VI.	1855	Roux.	Punctured wound of axilla.	Ligation of second portion; amputation at shoulder.
VII.	1856	Pitha	Rupture of circumflex artery in reducing dislocation; high axillary aneurism.	Ligation of second portion.
VIII.	1859	Cuveiller.	Bayonet - wound; subclavian aneurism.	Ligation of first portion; also of common carotid.
IX.	1862	Langenbeck, No. 1.	Stab-wound; diffuse subclavio-axillary aneurism.	Ligation of second portion.
X.	1882	Thiersch.	Punctured wound, outer part; subclavio-axillary aneurism.	Ligation of third portion; incision of sac; tried to ligate both ends, but could not find them.
XI.	1884	Langenbeck, No. 2.	Bullet-wound (side not mentioned); subclavio-axillary aneurism.	Incision of tumor; ligation of both ends.
XII.	1884	Langenbeck, No. 3.	Knife-wound (side not mentioned); subclavio-axillary aneurism	Sawing through clavicle; ligation of both ends.
XIII	1889	Lewtas.	Shot-gun wound; subclavian aneurism, wound close to anterior scalene.	Ligation of innominate and of common carotid.
XIV.	1893	Miles.	Gunshot wound; subclavian aneurism.	Provisional loop ligature on first portion; incision of sac; ligation of both ends.
(?)	1890	Twyman.	Wound from fractured clavicle of first portion of subclavian; pseudo-supraclavicular aneurism.	Ligation of innominate and of carotid.

Third Portion of the Right Subclavian Artery.

Complications.	Result	Remarks.	References.
Hæmorrhage.	Death.	Pleura wounded.	Edinburgh Medical and Surgical Journal, Vol. XI; Norris's Contributions to Practical Surgery, Philadelphia, 1873; Arch. klin. Chir., Bd. X; Wyeth's Essays, p. 170.
Hæmorrhage.	Cure.	Day before, patient had coughed up contents of sac.	London Medical Repository, 1823, Vol. XX, p. 190; Wyeth's Essays, p. 178.
Pyæmia; exhaustion.	Death on 8th day.	. . . .	Chelius's System of Surgery; Norris's Contributions; Guy's Hospital Reports; Wyeth's Essays, p. 164.
Hæmorrhage (?)	Death.	Side not positively stated.	Arch. klin Chir., Bd. X, p. 228; Wyeth's Essays, p. 188.
Hæmorrhage.	"	Proximal end closed by clot; distal end open.	Guy's Hospital Reports, XV; Wyeth's Essays, p. 172.
Hæmorrhage.	"	. . . .	Quarante Années de Pratique Chirurgicale; Wyeth's Essays, p. 175.
Pneumonia.	"	Tumor size of a man's head.	Wyeth, op. cit., p. 175; Arch. klin. Chir., Bd. X.
Hæmorrhage.	"	Distal end of subclavian opened; proximal end closed; carotid closed.	Gazette des Hôpitaux de Paris, 1860, XXIII, 130; Guy's Hospital Reports, p. 130; Arch. klin. Chir., Bd. X; Wyeth's Essays, p. 174.
Pyæmia.	"	Thrombus on either side of artery.	Wyeth, op. cit., p. 176; Arch. klin. Chir., Bd. X.
Hæmorrhage and pyæmia.	"	. . . .	Jaccoud's Dictionary, 1882, Article Artère Sous-Clávière, Georges Poinsot, p. 419; Arch klin. Chir., Bd X, p. 236; also Wyeth's Essays, p 204.
Hæmorrhage repeated.	Cure.	There was formation of a slowly-developing hæmatoma; side not stated.	London Medical Record, August 15, 1884; American Journal Medical Sciences, 1884, Vol. LXXXVIII, p. 589.
Pyæmia.	Death.	Considerable effusion of blood in walls of thorax; side not stated.	London Medical Record, August 15, 1884; American Journal Medical Sciences, 1884, Vol. LXXXVIII, p. 589.
None.	Cure.	Incision of sac; removal of clots; no ligation of wounded end of artery.	British Medical Journal, August 10, 1889, p. 312.
None.	"	. . . .	Medical News, Philadelphia, August 19, 1893.
Cerebral complications.	Death.	Is a case of pseudo-supraclavicular aneurism; great swelling in supraclavicular space, simulating aneurism of the third portion.	London Lancet, 1890, Vol. I, p. 1352.

DEDUCTIONS. RIGHT TRAUMATIC ANEURISMS.

By studying these fourteen cases closely the following facts force themselves prominently upon a surgical mind:

Some cases were accompanied with little swelling and others with much; these were more difficult, of course.

Some of the cases were subclavio-axillary or high axillary aneurisms, but with much swelling in the supraclavicular region, making them practically aneurisms of the third portion as far as the treatment is concerned.

Out of fourteen operated cases of right traumatic aneurism, three recovered (Bullen, Lewtas, Miles).

The innominate was ligated alone in one case (Arendt), the patient succumbed to exhaustion, probably due to pyæmia.

The innominate and the common carotid were ligated simultaneously in two cases; Lewtas's case recovered. Twyman's patient died of cerebral complications.

The first portion of the subclavian alone was ligated in two cases (Colles No. 1, Auvert); both cases died of hæmorrhage.

The first portion and the common carotid were ligated simultaneously in one case (Cuveiller), the patient died also of hæmorrhage.

The second portion was ligated in three cases (Roux, Pitha, Langenbeck, No. 1); all died; one died of hæmorrhage (Roux), one of pneumonia (Pitha), and one of pyæmia (Langenbeck, No. 1). Dr. Wyeth says that in five cases where the subclavian was ligated in its second portion for aneurism and other causes, it has proved as invariably fatal as in the first portion.[33]

Our table does bear out the statement of Wyeth that the ligature of the second portion on the right side is as unsafe as that of the first portion. So that every effort should be made to avoid the application of the ligature there; but when the necessity still exists, the scalene should be completely divided and all the neighboring branches tied on either side of two ligatures between which the main trunk should be divided and each end twisted securely, when it is not involved in the disease to such an extent as to contra-indicate torsion.[34]

The close proximity of the first and second portions of the right subclavian to the heart, and their position causing them to receive the full and direct force of the heart's action, is said to be the cause of the failure of the ligation of the first and second portions.

Dr. Wyeth is entitled to much credit for the perspicacity displayed in establishing this fact, which will be the saving of many lives.

The third portion was ligated in three cases (Colles, No. 2, Bullen, and Thiersch); one died (Colles) of pyæmia and gangrene.

The third portion was ligated previous to incising the sac in one case (Thiersch), and an anxious search was made for the two ends of the wounded artery to tie them, but they could not be found. The patient had a terrific secondary hæmorrhage, but he finally recovered.

The sac was incised without any previous ligation of any kind and the two ends ligated in one case (Langenbeck No. 2); there was hæmorrhage, of which the patient recovered, but he finally died of pyæmia.

In one case (Langenbeck, No. 3) the clavicle was sawn through and the two ends ligated; the patient died of pyæmia.

In one case a provisional ligature was applied by our lamented Miles, for the first and only time, on the first portion of the subclavian; the sac was incised and the two ends ligated; the patient recovered.

In several cases only one ligature was applied and no attempt was made to incise the sac, turn out the clots, and ligate the two ends.

Although two cases (Bullen and Lewtas) recovered after simply ligating the artery, such cases being still more numerous on the left side, yet the incision of the sac, and especially the ligation of the two ends, is in thorough accord with the Anglo-Saxon ideas of treating traumatic aneurisms.

It insures against any possible distal hæmorrhage and prevents all recurrent aneurisms.

However, the advantages of the Miles provisional ligature are gained at the expense of two regular operations, both somewhat risky; the incision of the sac which is exposed to suppuration and sepsis, and the ligation of the first portion of the subclavian; risky also in the possibility of accidentally wounding the pleura, the nerves, or the right lymphatic duct, and in creating a second focus of possible suppuration and sepsis.

Some may justly say that Miles's provisional ligature was an unnecessary operation, since in several cases, especially on the left side, the third portion was ligated, although so much swelling existed that the wound was three inches deep and was very narrow and dark. But this was one of those very rare "fortunate mistakes," because it brought out a new procedure which, although misapplied in the Miles case, yet called the attention of the profession to a procedure which constitutes a real progress in curing some cases which otherwise would be surely lost.

Thus in many cases, by applying a provisional ligature on the second portion, the wounded third portion could have been ligated safely, and thus many lives saved.

Similar provisional ligatures had before this one been applied to the other large arteries of the region.

In 1884, Walter Rivington placed a provisional ligature on the common carotid, while the bleeding-point was being searched for. It was in a case of wound of the parotid gland; no hæmorrhage at the time of entrance in hospital; suture; on eighth day secondary hæmorrhage stopped by pressure; erysipelas; abscess; incision; return of hæmorrhage; catgut provisional ligature of common carotid; ligation of bleeding vessel; recovery.[35]

In 1888, at a meeting of the Medical Society of London, Frederic Treves described a plan of exposing the carotid and passing a thread of catgut around it; if the loop thus formed was pulled up, pulsation in the artery stopped; if it were released, circulation went on again; by this means circulation could be controlled while the bleeding smaller branches were searched for and ligated. He referred to four instances in which this manœuvre had been carried out successfully.

One great recommendation of the method was that there were no great risks from the operation itself, and there was no local inflammation in any of the four cases. Mr. Treves says also that no obstruction of the vessel had followed in the cases he had related.[36]

A somewhat analogous case is on record in that region, the one of Dr. Peixoto, of Portugal. In 1851 he placed a moderately tight precautionary or expectant ligature around the innominate on account of secondary hæmorrhage from the common carotid, which had been ligated three weeks previously.[37]

However, we should also bear in mind that after incising the sac and turning out the clots, it is possible that the two ends may not be found, as it happened to the celebrated Thiersch, hence hæmorrhage and all its possible consequences.

It is preferable therefore to ligate the third portion, if possible, and await developments before opening the sac and ligating the two ends.

The complications were in a general way: operative hæmorrhage in eight, pyæmia in four, pneumonia in one, cerebral symptoms in one (Twyman).

Lewtas's and Miles's cases were the only two that presented no complications.

The relative frequency and gravity of each complication can only be studied profitably and with justice in connection with the ligation of each portion of the artery.

We must not lose sight of the fact that almost all these operations belong to the pre-aseptic period, and there is no evidence that those performed since that era have been done as thoroughly antiseptically as is required, and with double absorbable ligatures without rupturing the coats. Hæmorrhage and pyæmia have no *raison d'être* to-day.

There are therefore three clinical forms of traumatic aneurisms.

(1) Traumatic aneurisms where the swelling, moderate or great, of the supraclavicular space does not prevent the reaching of the artery through this region.

(2) Traumatic aneurisms where the swelling of the region is such that it is impossible to reach the artery in that locality.

(3) Traumatic aneurisms where the artery is found wounded near the outer edge of the scalene.

Traumatic Aneurisms with Moderate Swelling.—In cases of traumatic aneurisms with moderate swelling it is the writer's belief that a *provisional* ligature can be applied as safely on the *second portion* as has been done on the first portion, and that this should be done in preference.

By perusing the record of the cases of the right and of the left aneurisms, it will be seen that in some cases the artery was reached at the depth of even three inches.

The scalene should be divided in part or in totality if necessary, taking care to avoid the phrenic nerve.

Therefore, in all cases of traumatic aneurism of the third portion, even in cases with marked swelling in the supraclavicular region, an attempt should be made to reach the third portion near the scalene, or, if necessary, the second portion between the scalenes, and pass around it a provisional loop ligature,—that is, a strong, thick silk thread, using an aneurism-needle with a movable point, if necessary; then, without attempting to make any knot, but simply by pulling firmly on the two ends of the thread, so as to raise the artery, arrest the circulation through it. If needs be, the index-finger of the other hand can press the artery against the thread.

The effect of this procedure should stop the pulsation in the tumor and in the axillary artery; however, the latter should be compressed in the axilla to secure against collateral circulation.

Then the sac should be incised and the clots turned out in order to reach the two ends and secure them, then the provisional ligature is removed.

In this way there is only one wound, and there is less risk of injuring the important structures which surround the first portion.

Traumatic Aneurisms with Excessive Swelling.—It is only in cases where this attempt has failed from excessive swelling of the region that the surgeon would be justified in placing the provisional ligature on the first portion with all the attending risks enumerated above.

Traumatic Aneurisms in which the Third Portion is Wounded near the Border of the Scalene.—In those cases where, after applying the provisional ligature and before or after incising the sac, the artery is found wounded near the outer edge of the scalene, too close to hold a ligature,—*i.e.*, less than half an inch,—the second portion of the artery should be ligated with a double or triple non-contiguous catgut ligature, without rupturing the coats of the vessel, after the manner recommended first by Senn.

Idiopathic or Spontaneous Aneurisms of the Third Portion of the Right Subclavian Artery.—A very large number of operations have been proposed and performed for idiopathic or spontaneous aneurisms, but with lamentable results, the very few cases which have recovered have done so almost accidentally as it were, there being so many failures to one recovery by the same procedure or by similar ones.[38]

They have been treated by needling, by the opening of the sac, by the ligation of the arteries of the region, by the extirpation of the sac, by amputation at the shoulder-joint.

Needling (after Macewen's Process).—Needling, after Dr. Macewen's process is highly recommended by Dr. C. Nancrede.[39]

It consists of driving long, slender needles into the sac with a view of irritating the surface, thereby causing the formation of adherent fibrinous clots. It is contra-indicated when the walls are thin.

The discussion which followed the reading of this paper, before the American Surgical Association, did not elicit much confidence in this mode of treatment over the others.

However, Dr. J. D. Bryant, of New York, says that the lease of life gained by the fine needle insertion method of Macewen (and galvano-puncture, its associated treatment) warrants a strong belief in the benefit of these expedients when employed singly or with ligature.[40]

Old Method.—Opening of the Sac and Ligature above and below.—There are two cases recorded of the operation by the old method of opening the sac and ligating above and below.

The first case is the one of Syme. It is a case in which was practised digital compression of the subclavian artery on the first rib through an incision made in the tissues covering it, previous to opening the sac.

It is not properly a case of pure subclavian aneurism but of the axillary at its junction with the subclavian, a subclavio-axillary, but it extends high up above the clavicle. Besides, Syme tried there a practice which others might be tempted to follow but for the timely warning of this present account.

This case is that of a man aged forty-seven years; violent jerk of the shoulder but no wound of the artery; large tumor in axilla extending above the shoulder; distinct aneurismal bruit, but no pulsation; rapid increase of tumor; it so extended above the clavicle that ligation of the subclavian was judged impossible; incision along the outer edge of sterno-mastoid through the platysma and fascia so as to allow a finger to be pushed down to the situation where the subclavian artery issues from under the scalenus anticus and lies upon the first rib; tumor then incised; violent gush of blood showed that the artery was not effectually compressed; plugging of the wound with hand; an assistant by a slight movement of his finger, which had been thrust deeply under the upper edge of the tumor through the clot, succeeded in getting command of the vessel; cavity of sac laid open; seven and a half pounds of coagulated blood removed; artery seemed to be torn across; free bleeding from lower end of artery which is secured; section of pectoral muscles close up to the clavicle and, holding the upper end of the vessel between finger and thumb, the operator passed an aneurism needle so as to apply a ligature about half an inch above the orifice; the elevation of the clavicle, which rendered the artery so inaccessible from above, facilitated this procedure from below; sutures; suppuration; six weeks after operation the patient was discharged; he is now in perfect health.

The skilful assistant of the great Syme on this eventful occasion was no less than the future immortal Lister himself.[41]

The second case was that of Dr. Smyth.

Upon the recurrence of the aneurism in his famous case, Dr. Smyth incised the sac with the hope of plugging the orifice of the artery, but the hæmorrhage was so fearful he had to desist and plug the sac with lint and apply a bandage; the man barely escaped death on the table; he died from the effects of the hæmorrhage after forty-eight hours.[42]

Ligations.—The history of the treatment by ligature may be told in very few words, since they almost all died; but it is of the utmost importance to study the manner in which the failures occurred.

It must be well understood all along that in the following descriptions of ligations we will only consider those that were performed for aneurisms of the third portion of the right subclavian. However, cases where the second and first portions were involved with the third will be considered.

LIGATIONS OF THE SUBCLAVIAN.

(1) *Ligation of the Third Portion alone of the Subclavian as a Proximal Operation.*—The third portion of the subclavian has been tied alone outside of the scalene muscles for aneurisms of the right subclavian low down, eleven times, with ten fatalities.

It is only possible when the tumor is small. It was done by Colles, Travers, Brodie, Green, Gore, Blaker, Stanley, Gregg, Drayton, Paget, Auvert.

I.—1813 or 1815. Colles. Man, aged forty-eight years; fall from a horse; subclavio-axillary aneurism; delirium and rapid gangrene of the limb; no clots on either side.[43]

II.—1823. Travers. Man, aged seventy-three years; subclavio-axillary aneurism; in passing needle the sac was penetrated; hæmorrhage; exhaustion; death.[44]

III.—1831. Brodie. Man, aged fifty years; subclavio-axillary aneurism; suppuration; death; coagula on both sides of ligature.[45]

IV.—Green. Man, aged thirty-five years; tumor small, on outer part of artery; ligature close to scalene; nerve of brachial plexus was included in the ligature; intense pain; removal of ligature; reapplication of ligature; never presented a bad symptom; cured; was seen several years after the operation and was quite well.[46]

V.—1851. Gore. Death.[47] No details obtainable.

VI.—1855. Blaker. Man, aged fifty-nine years; subclavio-axillary aneurism; hæmorrhage; death; proximal side open; distal side full of purulent matter.[48]

VII.—1856. Stanley. Man, aged forty years; subclavio-axillary aneurism; pleuritis; death; purulent infiltration of tissues around wound.[49]

VIII.—Gregg. Man, aged forty years; pyæmia and hæmorrhage; death; cardiac end closed; distal end open.[50]

IX.—1859. H. E. Drayton. Man, aged thirty-seven years; subclavio-axillary aneurism; due to a fall; phlebitis; coma; no hæmorrhage; death; artery closed on both sides of ligatured point.[51]

X.—1860. Paget. Man, aged fifty-four years; subclavio-axillary aneurism; hæmorrhage; death; sac suppurated; distal end closed; cardiac end closed; hæmorrhage, probably from branches connecting with sac.[52]

XI.—1858. Auvert. Man, aged thirty-six years; subclavio-axillary aneurism; pneumonia; hæmorrhage; death; rupture of artery at site of ligature.[53]

(2) *Ligation of the Second Portion of the Subclavian alone,—i.e., between the Scalenes.*—There are only two cases, by Liston and Gay, of ligation of the second portion of the right subclavian alone between the scalenes for spontaneous aneurism of the third portion.

The *first case* is the one of Liston. A subclavio-axillary aneurism, caused by a fall on the ice with the arm outstretched; the aneurism extended to near the scalenes; enormous swelling; nine months' duration; the artery was first tied in the third portion, but, being involved in the disease, a ligature was placed behind (between) the scalenes, on the second portion; hæmorrhage; death on fourteenth day; the vessel had given way near the external of the two ligatures, the innermost one having become loosened; both proximal and distal ends of the subclavian were opened.[54]

The *second case* is that of Gay. A subclavio-axillary aneurism; ligature between the scalenes; there was no pulsation in the subclavian when reached in the operation; death on the nineteenth day of bronchitis; thrombi on both sides of the ligature; death believed to be due to the bronchitis and not in any way connected with the operation or its results; "so far, the operation might be claimed to have been successful."[55]

We must remember that Wyeth says that the ligation of the second portion on the right side was fatal in five cases where it was applied, for whatever cause. Some cases were for traumatic aneurisms and some for other causes. It should be avoided, he says, but, if this is impossible, then the scalene should be completely divided and all the neighboring branches tied on either side of the two ligatures, between which the main trunk should be divided and each end twisted securely.[56]

However, by using a double or triple non-contiguous ligature, without rupturing the coats of the vessel, the operation may succeed. It is less dangerous than ligating the first portion.

(3) *Ligation of the First Portion alone of the Right Subclavian.*—The ligature of the first portion of the right subclavian

alone for spontaneous aneurism of the third portion has been done eight times, by Arendt, Bayer, Liston, Mott, Hayden, O'Reilly, Partridge, and Auvert.

I.—1826. Arendt. No details obtainable; death on fourth day.[57]

II.—1829. Bayer. Man, aged twenty-one years; subclavio-axillary aneurism; hæmorrhage; rupture of sac; death.[58]

III.—1830. Liston. Man, aged thirty-two years; subclavio-axillary aneurism; hæmorrhage; death; central end subclavian closed by clot; distal end open.[59]

IV.—1831. Valentine Mott. Female, aged twenty-one years; hæmorrhage; death.[60]

V.—1832. G. T. Hayden. Female, aged fifty-seven years; hæmorrhage; death; artery ruptured at point of ligation.[61]

VI.—1833. O'Reilly. Male, aged thirty-nine years; hæmorrhage; death.[62]

VII.—1841. Partridge. Male, aged thirty-eight years; pyæmia; death fourth day; no clot on either side of artery.[63]

VIII.—18—. Auvert. Man, aged thirty-six years; subclavio-axillary aneurism; hæmorrhage; pneumonia; death; proximal end closed; distal end open.[64]

(4) *Simultaneous Ligation of First Portion of the Right Subclavian and of the Common Carotid.*—There is only one case on record of simultaneous ligature of the first portion of the right subclavian artery and of the common carotid for spontaneous aneurism of the third portion.

It is the case of Liston (1838). Man, aged thirty-one years; aneurism said to be traumatic, but not truly so, of six months' standing; fainting, collapse, cerebral symptoms, dyspnœa, hæmorrhage, death; pus in the mediastinum; pericarditis; innominate closed firmly; carotid closed, subclavian open, as also vertebral and other intermediate branches; the hæmorrhage had come from the distal end of the subclavian.[65]

Care was taken to ligate the first portion of the subclavian close to the innominate to have sufficient space between the ligature and the origin of the collateral branches for a clot to form; this space is from one and a quarter to one and a half inches.

To insure a clot in the innominate, it was necessary to ligate the common carotid.[66]

The common carotid is ligated simultaneously to prevent distal secondary hæmorrhage. This was not likely to happen, since the distance between the bifurcation and the point of ligation was quite considerable, but it had happened with the subclavian when the distance between the ligature and the origin of the first large collateral branch was reasonable.

The ligature of the common carotid simultaneously with the subclavian was also to allow occlusion of the proximal end of the subclavian, which would not take place if the current swept freely from the innominate into the common carotid.[67]

(5) *Simultaneous Ligation of First Portion of the Right Subclavian, Common Carotid, and Vertebral.*—To guard against hæmorrhage through the distal end of the subclavian, the ligation also of the vertebral was advised by Kearney Rodgers (who had operated on the left side).

There is only one case of simultaneous ligation of the first portion of the right subclavian, common carotid, and vertebral, and that is the case of Willard Parker, of New York.

The aneurism was above the centre of the right clavicle. The patient died of distal hæmorrhage from the subclavian on the second day; the proximal end of the vertebral had ulcerated through.

The operation was performed at the New York Hospital on September 3, 1863.[68a]

Gross says it was on the left side, but the autopsy was made by Sands,[68b] and he mentions the right side every time. Besides, Wyeth says he obtained his notes from Parker himself.

Ligation of the first portion of the subclavian has been done ten times alone, or simultaneously with other arteries, for idiopathic subclavian aneurism of the third portion, and all resulted fatally. Arendt, Bayer, Liston (1830), Mott, Hayden, O'Reilly, Partridge, Auvert, Liston (1838), Willard Parker.

They all died of distal hæmorrhage from the subclavian except one case (Partridge) which died of pericarditis, pleuritis, and pyæmia; and one (Arendt) who died of exhaustion.

After all these disastrous results, the subclavian is abandoned as decidedly refractory to the operation, and the efforts are henceforth directed on the innominate.

(6) *Ligation of the Innominate Alone.*—The ligature of the innominate alone is as easy as that of the subclavian; it is less dangerous, not being so closely in relation with the pleura, the nerves, and the right lymphatic duct.[69]

There exist fourteen cases of ligature of the innominate alone for subclavian aneurism of the third portion. We include in this number cases called simply subclavian aneurisms, when the portion affected is not mentioned specially.

Those cases belong to Mott, Graefe, Norman, Dupuytren (the unknown), Hall, Bland, Lizars, Gore, Pirogoff, Porter, Bickersteth, O'Grady, Thompson, May.

I.—1818. Valentine Mott, New York. Man, aged fifty-seven years. Fall on shoulder; first portion diseased; ligation of innominate one-half inch below the bifurcation; tumor reduced one-third in size; left carotid became very much dilated; suppuration; hæmorrhage from wound; death; innominate not closed on proximal side; on distal side, ulceration of innominate, carotid, and subclavian; subclavian pervious throughout; carotid not quite occluded.[70]

II.—1822. Graefe, Berlin. Man, aged (?) years. First portion of subclavian involved; ligation of innominate one inch from aorta; hæmorrhage; death on sixty-seventh day; proximal end closed perfectly; distal end open.[71]

III.—1824. Norman, Bath. Man, aged (?) years. Hæmorrhage; death; no details obtainable.[72a]

IV.—183-.(?) Unknown. Reported by Dupuytren. Man, aged (?) years. Hæmorrhage; death on third day; no details obtainable.[72b]

V.—1830. Hall, Baltimore. Man, aged fifty-two years. Innominate diseased and dilated; after ligation, hæmorrhage from wound; death; pericarditis; aneurism-needle had partially transfixed artery accounting for hæmorrhage.[73]

VI.—1832. Bland, Sidney. Man, aged thirty-one years. Repeated hæmorrhages; death; proximal end closed; carotid closed completely; subclavian open.[74]

VII.—1837. Lizars, Edinburgh. Man, aged thirty years. Fall on right arm; suppuration; ligature loose on seventeenth day;

hæmorrhages from wound; death; hæmorrhage into the pleura; central end of innominate not entirely closed; subclavian pervious; hæmorrhage supposed to have come from subclavian and vertebral.[75]

VIII.—1856. Gore, Bath. Man, aged fifty-two years. Erysipelas; terrible hæmorrhage and death; cardiac end only partially closed; both subclavians closed; carotid of right side open.[76]

IX.—1856. Pirogoff, St. Petersburg. Man, aged forty-six years. Paralysis of left side of the face; death in forty-eight hours; pleuritis and pneumonia.[77a]

X.—1867. G. H. Porter, Dublin. Man, aged (?) years. Clamp applied for three days to innominate and then removed; pleuritis, pneumonia; death.[77b]

XI.—1868. E. B. Bickersteth, Liverpool. Man, aged forty years. First used a lead wire, replaced on second day by two silk ligatures; hæmorrhages; lead shots poured into wound; death; clot firm in innominate on cardiac side; subclavian occluded; carotid open.[78a]

XII.—1873. O'Grady, Dublin. Great shock; death after twenty hours.[78b]

XIII.—1882. Thompson, Dublin. Man, aged (?) years. Hæmorrhage; death.[79a]

XIV.—1886. Bennett, Birmingham. Man, aged thirty years. Large aneurism above the inner half of the clavicle. The common carotid artery is carried inward towards the middle line of the neck; pulsations very strong; all the superficial arteries are slightly fibroid; no evidence of disease of the heart or of the large blood-vessels; ligature of the innominate artery; it was rather superficial; it seemed to be unusually large, nearly an inch in diameter; compression made against the sternum by a finger behind the vessel controlled the pulsations both in the tumor and the carotid; structures over bifurcation and first portion of the subclavian much matted and could hardly be identified; also adhesion of innominate to sternum, hence difficulty of passing needle around; ox-aorta ligature; considerable force required in tightening, to stop the pulsations; breaking of the ligature; second ligature of same nature; also broke; made a ligature of six medium-sized threads of catgut; ligature tightened so as not to rupture the coats; operation under spray and careful Listerian antiseptic details; two weeks after, hæmorrhage, death; aneurism involved third portion partly, second portion mainly, first portion partly; no pus; ulceration along both sides of the ligature of the size of small pea.[79b]

(Dr. H. L. Burrell, of Boston, has reported a case of successful ligation of the innominate at the meeting of the American Surgical Association in New York, May 28, 1875. But it was for an aneurism at the root of the subclavian and common carotid.)

(7) *Simultaneous Ligation of the Innominate and Common Carotid.*—There are two cases by Mott and Coppinger where the innominate and the common carotid have been ligated simultaneously.

The *first case* is that of A. B. Mott, 1868. Man, aged (?) years; hæmorrhage in thorax: sac ruptured in pleural cavity.[80]

The *second case* is that of Dr. Charles Coppinger, surgeon to the Mater Misericordiæ Hospital of Dublin. Success depended upon keeping the wound aseptic. Man, aged fifty-three years. Came under treatment December 5, 1892; aneurisms of third and second portions of subclavian; size of a hen's egg; tense and elastic; vibrating thrill; apparently about to burst; also in the axilla tumor size of a walnut; also under clavicle a pulsating swelling; operation on January 9, 1893; common carotid ligated in two places and divided between; ligature of innominate; silk ligatures used; mindful of Dr. Banks's case, the operator abandoned the hope of being able to effectually tie kangaroo tendon in such a difficult situation, and therefore worked with silk; strict antisepsis; operation lasted thirty minutes.[81]

Six weeks after the operation the aneurism was still very perceptible as a large soft tumor in the patient's neck; it was entirely without pulsation, while, moreover, no pulse could be felt in either his right wrist or arm.[82]

The case was exhibited in the Section of Surgery of the Royal Academy of Medicine of Ireland.

At the time of the presentation, Mr. W. Thompson joined in the congratulations and said he took a special interest in the case, as he had gone through all the torture of failure when he thought he had obtained success. In the book he wrote on ligation of the innominate, he said very emphatically that if another such case came before him he would not hesitate to operate, because he believed the operation was one which must be successful.

He said he lost his case by the prolonged use of the drainage-tube, whereas in Coppinger's case there was an opportunity given for the rapid adhesion of all parts of the wound, and to this he attributed the success which had followed. In his own case there had been no suppuration in the wound, and it remained open for a considerable time.[83]

On July 4, 1895,—*i.e.*, over two years after the operation,—the patient had been in St. Bartholomew's Hospital, because his nervous system seemed somewhat broken down, but he was quite free from any sign of his old aneurism.[84a]

This case is now truly the culminating point in the history of the treatment of this disease by proximal ligation. Thus Coppinger stands the champion of proximal ligations.

However, the aneurism may yet return, as was exemplified in Smyth's case, soon to be mentioned.

(8) *Simultaneous Ligation of the Innominate, Common Carotid, and Vertebral.*—There are two cases of simultaneous ligature of the innominate, common carotid, and vertebral for subclavian aneurism of the third portion.

They are the cases of Bull and of Durante.

The case of Bull is most briefly reported wherever it is found; a double ligature of catgut was employed; hæmorrhage followed, and death supervened on the thirty-third day.[84b]

The case of Professor F. Durante, of Rome, Italy, was reported at the fourth meeting of the Italian Society of Surgery, April 4 to 7, 1887.[85]

Man, aged forty-five years. No apparent cause; tumor size of a large lemon protruding in the supraclavicular fossa; clavicle partly corroded; ligature of innominate, common carotid, and vertebral; on tenth day blood flows from the drainage-tube; it is checked by moderate but prolonged digital pressure; on same day hemiplegia of *right* side, which disappears in half a day, leaving paralysis of the face and tongue; death; near the ligatures the arterial walls appear almost completely dried, without phlogistic reaction; small coagulum near common carotid above ligature; aneurismal sac contains coagula of various consistence; brain presents embolic softening of left caudate nucleus; the embolism proceeded from the central portion of the thrombus, which, having undergone fatty degeneration, presented but few traces of organization.

Henderson says that the innominate was tied in two places,—viz., immediately below the junction of the subclavian and common carotid, and again slightly lower down. The vertebral was tied also. Henderson does not speak of the carotid, but Durante, in his private communications, states positively that the common carotid was also tied.[86]

Twyman says that apoplectic symptoms have been noted as occurring more than once in this operation. Out of twenty-two accepted cases collected from Erichsen's "Surgery" and Spencer's list, and including Lewtas's case and his own, cerebral symptoms have occurred in three.[87]

(9) *Simultaneous Ligation of the Innominate and Common Carotid, and, later, of the Vertebral.*—There is only one case on record of the simultaneous ligature of the innominate and common carotid, followed *fifty-four days later* by the ligation of the vertebral artery, for an aneurism of the third portion of the subclavian. It is the case of Dr. Andrew W. Smyth, of New Orleans, La.

(Chronologically this case should precede the others, but in a methodical description its proper place is here.)

A mulatto, aged thirty-four years. Right aneurism of the third portion, due to efforts made by the patient in catching at an anchor in trying to save himself from drowning in a collision at sea.

The innominate and common carotid were ligated on May 15, 1864; secondary hæmorrhage; ligature of the vertebral on July 9, 1864; the patient left the hospital apparently cured; ten years later he came back with the tumor as large as before; the internal mammary was ligated without any benefit; the sac, threatening to burst, was opened, with the hope of plugging the opening of the aneurismal artery, but in vain; plugging *en masse;* patient died of hæmorrhage within forty-eight hours; at autopsy (made by the writer), the recurrent collateral circulation took place through the anastomoses of the perforating branches of the aortic intercostals with the branches of the subscapular.[88]

The specimen is now preserved in the Army Medical Museum at Washington. (See Appendix.)

Smyth says he conceived the idea of ligating the vertebral from reading in Erichsen the enumeration of the anastomotic branches which carried on the collateral circulation.[89a]

For many long years this startling achievement stood in grand loneliness and splendor, a radiant beacon-light on these dark seas.

(10) *Simultaneous Ligation of the Innominate and Common Carotid, and Sixty-seven Days later, of First Portion of Subclavian.*—There is only one case on record of the simultaneous ligature of the innominate and common carotid, necessitating sixty-seven days later the ligature of the third portion of the subclavian. It is the celebrated case of Mitchell Banks, of Liverpool, in 1885.

Man, aged fifty years. Well-marked symptoms of aneurism of third portion of right subclavian; ligature of innominate and of common carotid with kangaroo tendon; pulsation became practically imperceptible; same evening, slight return of pulsation; by third day the pulsation is strong. Sixty-seven days later, ligation of first portion of subclavian; operation difficult and dangerous because of matted condition of tissues owing to first operation; on the twenty-third day after the last operation, hæmorrhage; death thirty-seven days after.[89b]

(11) *Ligation of the Third Portion of the Subclavian as a Distal Operation for Aneurism of the Third Portion of the Right Subclavian.*—Having been repulsed so often on the proximal side, the desperate surgeons attacked the disease on the distal side.

There is only one case of distal ligation of the third portion, with the aneurism between the ligature and the heart, *for an aneurism of the third portion.*

It is the case of Dr. Charles Monod, of Paris, France, upon which Professor Paul Berger read a masterly report to the Academy of Medicine of Paris. The common carotid was ligated simultaneously.

Man, aged fifty-one years. Tumor size of a small hen's egg; it is limited below and outward by the clavicle; it is lost towards the base of the neck in the deep region, without enabling to determine whether or not it was prolonged to the scalene.

The two radial pulses are alike; the compression of the axillary artery is without effect on the tumor, whereas the compression of the carotid at the neck diminishes very notably the intensity of the pulsations of the tumor. Professor Berger thinks that this was due to the extension of the aneurism to the second and first portions of the subclavian. Attempted to ligate the innominate, but it is found very deeply seated, dilated, and thinned, so the idea was abandoned. Ligation of the outer part of the third portion of the subclavian between the tumor and the clavicle; the space was very limited. Also ligation of the common carotid in order to prevent recurrent circulation and also because compression on this artery affected the intensity of the pulsations of the aneurism.

Four months after the operation all vestiges of the tumor have disappeared; the radial and the brachial pulse on the same side are still absent.[90]

In a personal communication, dated June 8, 1895, Dr. Monod states that his patient is still enjoying good health; he has no pain, but the radial pulse is still absent; there is a slight atrophy and stiffness of the forearm, wrist, and hand; these, however, are gradually improving.

(12) *Ligation of the Axillary alone as a Distal Operation on the Right Side.*—The ligature of the axillary artery alone as a distal operation on the right side has been employed five times, and in each instance certainly did no good, but probably hastened the fatal termination. Too many vessels are given off by the diseased part of the artery.[91]

Agnew states that it has been done by Dupuytren, Shuck, Canton, Pétrequin, and all died.[92a]

18—.—Dupuytren. Man, aged forty years. Tumor size of a hen's egg; artery ligated below clavicle; hæmorrhage from wound; syncope and death on the eighth day; no clot in artery at point of ligature; small opening in artery; subclavian diseased throughout.[92b]

1863.—Canton. Man, aged thirty-two years. Compression of axillary arrested pulsations in sac; artery tied at the edge of the coraco-brachial, tumor ceased immediately to pulsate; death eighteen days later; no cause stated.[92c]

18—.—Pétrequin. This case is more an aneurism of the first and second portions.[92d]

18—.—Shuck. No details obtainable (writer).

Wyeth says it was done three times and they all died.[93a]

On the same principle Butcher tied the carotid in one case, which ended fatally.[93b]

1863.—Butcher. Man, aged forty-two years. Tumor size of half of a large apple; the first portion diseased, and the innominate also; the right carotid was ligated three-quarters of an inch above its origin; two days later, sudden death; no clot in carotid; axillary filled with clots.[94]

Extirpation of the Sac on the Right Side.—There is one case only on record where extirpation of the aneurismal sac was resorted to on the right side, but it was for a persistent, solidified, or obliterated aneurism, by Franz Schopf, of Vienna.

Man, aged forty-six years; right subclavio-axillary aneurism of the size of a man's fist; is soft, yet elastic; no pulsation, no fremitus; upper extremity emaciated; movements limited and painful; no radial pulse; no œdema; no cyanosis, showing that the vein was free; trophic ulcer on the metacarpo-articulation of the little finger, of the size of a penny, communicating with the joint; it was thought that the tumor might be a neoplasm because the patient could not say if there had been pulsation or if the tumor had been softer or compressible; extirpation undertaken; is rather difficult, as the entire brachial plexus was intimately adherent to the sac; the pectoral muscle was divided transversely; the portion of the artery on the distal side of the tumor was obliterated and contracted to the size of a lead-pencil; the central portion of the vessel was of the size of the little finger and pulsating forcibly; it was ligated high up under the clavicle with strong silk; the axillary vein was separated with great difficulty without injury to its walls; finally, removal of the sac; it is a thick-walled aneurismal sac filled with firm blood-clots; primary union; persistence of fistula for three months; soon after the operation the ulcer healed with a good joint; pains and numbness disappeared; the use of the upper limb improved. Of course, if the tumor had caused no serious symptoms, it would not have been removed.[95]

Amputation at the Shoulder-Joint on the Right Side.—The operation proposed by Ferguson, amputation at the shoulder-joint and ligating the artery as close as possible to the sac (Erichsen), was performed five times with two recoveries (no side mentioned).[96]

It was done on the right side by Rose, with partial success. Rose also tied the carotid, and thus succeeded in saving his patient.[97]

FIFTY-SEVEN IDIOPATHIC ANEURISMS OF THE THIRD

	Operations.		Operators.	Complications.
I.	Needling.		Macewen.	. . . .
			Nancrede.	. . . .
			Bryant.	. . . .
II.	Opening of the sac and ligation of artery.		Syme.	Considerable hæmorrhage.
			Smyth.	Terrific hæmorrhage.
III.	Proximal ligations. A. Ligation of the Subclavian. (1) Ligation of the third portion alone.	I.	1813. Colles.	Rapid gangrene.
		II.	1823. Travers.	Hæmorrhage; needle had penetrated sac.
		III.	1831. Brodie.	Suppuration.
		IV.	1844. Green.	. . . .
		V.	1851. Gore.	. . . .
		VI.	1855. Blaker.	Hæmorrhage.
		VII.	1856. Stanley.	Pleuritis.
		VIII.	1857. Gregg.	Hæmorrhage; pyæmia.
		IX.	1859. Drayton.	Phlebitis; coma.
		X.	1860. Paget.	Hæmorrhage.
		XI.	1858. Auvert.	Hæmorrhage; pneumonia.
	(2) Ligation of second portion alone.		1826. Liston.	Enormous swelling; artery tied first in third portion, then in the second.
			1871. Gay.	Bronchitis.
	(3) Ligation of the first portion alone.	I.	1826. Arendt.	Exhaustion (?)
		II.	1829. Bayer.	Hæmorrhage from rupture of the sac.

Portion of the Right Subclavian Artery.

Result.	Remarks.	References.
Contested.	Contra-indicated when the walls are thin.	
. . . . . .	. . . .	Charles B. Nancrede, Trans. Am. Surg. Asso'n, 1893, Vol. IX, p. 115.
. . . . . .	. . . .	J. D. Bryant, Am. Lancet, Detroit, January, 1893, quoted in Sajous's Annual, 1893.
Cure.	Difficulty in securing the ends of the artery.	James Syme, Med. Chir. Trans., London, 1860, Vol. XLIII, p. 141; also Syme's Operations of Clinical Surgery, p. 141; also quoted by Lefort in Dechambre's Dictionary, 1881; article "Subclavian Aneurism."
Death.	No time to find the opening of the artery.	Archives of Charity Hospital, New Orleans, La., 1876.
"	Subclavio-axillary aneurism; no clots on either side.	Guy's Hospital Reports, Poland, Vol. XV, p. 68; Wyeth's Essays, p. 176.
"	Subclavio-axillary aneurism	Guy's Hospital Reports, Vol. XV, p. 69; Wyeth's Essays, p. 178.
"	Subclavio-axillary aneurism. Coagulation on both sides of the ligatures.	Guy's Hospital Reports, Vol. XV, p. 69; Wyeth's Essays, p. 180.
Cure.	Tumor was small on the outer part of the artery; ligature close to the scalene. Was seen many years after the operation and was quite well.	Guy's Hospital Reports, Vol. XV, p. 70; Wyeth's Essays, p. 188.
Death.	. . . .	Guy's Hospital Reports, Vol. XV, p. 73; Wyeth's Essays, p. 190.
"	Subclavio-axillary aneurism, proximal end open, distal end full of pus.	Guy's Hospital Reports, Vol. XV, p. 70; Wyeth's Essays, p. 192.
"	Subclavio-axillary aneurism; purulent infiltration around wound.	Arch. klin. Chir., Bd. X, p. 232; Wyeth's Essays p. 192.
"	Cardiac end closed, distal end open.	Guy's Hospital Reports, Vol. XV, p. 72; Wyeth's Essays, p. 192.
"	Subclavio-axillary aneurism; artery closed on both sides	Am. Journ. Med. Sci., October, 1859, p. 402; Wyeth's Essays, p. 192.
"	Subclavio-axillary aneurism; sac suppurated; both ends closed.	Guy's Hospital Reports, Vol. XV, p. 70; Wyeth's Essays, p. 194.
"	Subclavio-axillary aneurism; rupture of artery at ligature.	Schmidt, Jahrbuch, Bd. XCVII, p. 341, 1858; Wyeth's Essays, p. 206.
"	Subclavio-axillary aneurism; both ends of subclavian open.	Guy's Hospital Reports, Vol. XV; Wyeth's Essays, p. 174.
"	No pulsation in artery when reached; thrombi on both sides of ligature.	Trans. Path. Soc., London, 1871, XXII, 111; London Lancet, 1871, p. 22; London Lancet, May, 1871, p. 611; Wyeth's Essays, p. 176.
Death on fourth day.	No details obtainable.	Klin. Chir., Bd. X; Wyeth's Essays, p. 70; Gross's Surgery, 1882, Vol. I, p. 756.
Death.	Subclavio-axillary aneurism.	Guy's Hospital Reports, Vol. XV, Poland; Wyeth's Essays, p. 170.

FIFTY-SEVEN IDIOPATHIC ANEURISMS OF THE THIRD

	Operations.	Operators.	Complications.
	III.	1830. Liston.	Hæmorrhage.
	IV.	1831. V. Mott.	Hæmorrhage.
	V.	1835. Hayden.	Hæmorrhage.
	VI.	1836. O'Reilly.	Hæmorrhage.
	VII.	1841. Partridge.	Pyæmia.
	VIII.	18—(?) Auvert.	Hæmorrhage; pneumonia.
	(4) Simultaneous ligation of first portion and of the common carotid.	1838. Liston.	Hæmorrhage from distal end of subclavian.
	(5) Simultaneous ligation of first portion of common carotid and vertebral.	Sept., 1863, Willard Parker.	Hæmorrhage from distal end of subclavian.
	B. Ligation of innominate. I. (6) Ligation of innominate alone.	1818. V. Mott.	Suppuration; hæmorrhage.
	II.	1822. Graefe.	Hæmorrhage.
	III.	1824. Norman.	Hæmorrhage.
	IV.	183-. Unknown; reported by Dupuytren.	Hæmorrhage.
	V.	1830. Hall.	Hæmorrhage; pericarditis; aneurism-needle had partly transfixed artery.
	VI.	1832. Bland.	Hæmorrhage.
	VII.	1837. Lizars.	Suppuration; hæmorrhage.
	VIII.	1856. Gore.	Erysipelas; terrible hæmorrhage.

PORTION OF THE RIGHT SUBCLAVIAN ARTERY.—(*Continued.*)

Result.	Remarks.	References.
Death.	Subclavio-axillary aneurism; central end of subclavian closed, distal end open.	Arch. klin. Chir., Bd. X; Wyeth's Essays, p. 170.
"	. . . .	Am. Journ. Med. Sci., Vol. XII; Norris's Contrib. to Pract. Surg; Guy's Hospital Reports, Vol. XV; Wyeth's Essays, p. 170.
"	Artery ruptured at point of ligation.	Arch. klin. Chir., Bd. X; Norris's Contrib. Am. Journ. Med. Sci., 1838; Wyeth's Essays, p. 170.
"	. . . .	Norris's Contrib. Am. Journ. Med. Sci., 1838; Wyeth's Essays, p. 170.
"	No clot on either side.	Norris's Contrib.; Guy's Hospital Reports, Vol. XV; Wyeth's Essays, p. 170.
"	Subclavio-axillary aneurism; proximal end closed, distal end open.	Guy's Hospital Reports, Vol. XV; Wyeth's Essays, p. 172.
"	. . . .	Guy's Hospital Reports, Vol. XVII; Wyeth's Essays, p. 172.
"	Proximal end of vertebral open.	Am. Med. Times, New York, March, 1864, Vol. VIII, p. 114; Am. Journ. Med. Sci., 1864, N. S. XLVII, 562; Wyeth's Essays, p. 173.
"	First portion diseased; innominate ligated ½ inch below bifurcation; innominate not closed on central side; on distal side, ulceration of innominate, carotid, and subclavian; subclavian pervious throughout; carotid not quite occluded.	New York Medical Repository, Vol. I, p. 1818; Norris's Contrib. to Pract. Surgery; Guy's Hospital Reports, Vol. XVII, Poland; Wyeth's Essays, p 162.
"	First portion involved; innominate ligated 1 inch from aorta; proximal end closed, distal end open.	Graefe and Walther's Journal, Bd. IV; Guy's Hospital Reports, Vol. XVII, Poland; Norris's Contrib.; Wyeth's Essays, p. 164.
"	No details obtainable.	Ferguson's Surgery, p. 429, Phila., 1845; Norris's Contrib.; Guy's Hospital Reports, Vol. XVII, Poland; Wyeth's Essays, p. 164.
Death on third day.	No details obtainable.	Dupuytren, Leçon's Orales, 1834, p. 611; Norris's Contrib.; Guy's Hospital Reports; Wyeth's Essays, p. 164.
Death.	. . . .	Norris's Contrib.; Baltimore Med. and Surg. Journ. and Review, 1833; Guy's Hospital Reports, Vol. XVII, Poland; Wyeth's Essays, p. 164.
"	Proximal end closed; carotid closed; subclavian open.	London Lancet, 1832, Vol. I, p. 97; Guy's Hospital Reports, Vol. XVII, Poland; Wyeth's Essays, p. 166.
"	Central end of innominate not entirely closed; subclavian pervious.	Norris's Contrib.; Lancet, Vol. II, p. 445; Guy's Hospital Reports, Vol. XVII, Poland; Wyeth's Essays, p. 166.
"	Central end of innominate only partially closed; both subclavians closed; carotid on right side open.	Erichsen; Guy's Hospital Reports, Vol. XVII, Poland; Lancet, July, 1878; Wyeth's Essays, p. 168.

FIFTY-SEVEN IDIOPATHIC ANEURISMS OF THE THIRD

	Operations.	Operators.	Complications.
	IX.	1856. Pirogoff.	Paralysis left side face; pleuritis; pneumonia.
	X.	1867. G. A. Porter.	. . . .
	XI.	1868. Bickersteth.	Hæmorrhage.
	XII.	1873. O'Grady.	Shock.
	XIII.	1882. Thompson.	Hæmorrhage from distal end.
	XIV.	1886. May.	Hæmorrhage.
	(7) Simultaneous ligation of the innominate and common carotid.	1868. A. B. Mott.	Hæmorrhage.
		1893. Coppinger.	. . . .
	(8) Simultaneous ligation of innominate, common carotid, and vertebral.	1884. Bull, New York.	Hæmorrhage.
		1887. Durante.	Hæmorrhage; cerebral embolism on left side.
	(9) Simultaneous ligation of innominate and common carotid, followed later by ligature of vertebral.	1864, May 15. Smyth.	Distal hæmorrhage from vertebral.
	(10) Simultaneous ligation of the innominate and common carotid, followed later by ligation of first portion of the subclavian.	1885. M. Banks.	Hæmorrhage.
IV.	Distal ligations A. Simultaneous distal ligation of the third portion of subclavian and ligature of common carotid.	1895. Monod.	Also dilatation of second and first portions.
	B. Distal ligation of axillary alone.	Dupuytren.	Hæmorrhage from wound.
		Canton.	. . . .
		Pétrequin.	. . . .
		Shuck.	. . . .
	C. Simultaneous distal ligation of axillary and common carotid.	Butcher.	. . . .
V.	Extirpation of the sac.	1891. Schopf, Fr.	. . . .
VI.	Amputation at the shoulder.	Five times.	. . . .

PORTION OF THE RIGHT SUBCLAVIAN ARTERY.—(*Concluded.*)

Result.	Remarks.	References.
Death after 48 hours.	. . . .	Allgemein, Krieg's Chir., 1864, p. 459; Guy's Hospital Reports, Vol. XVII, p. 137; Wyeth's Essays, p. 168.
Death.	Clamp applied for three days.	Med. Press and Circular, Dublin, 1867, pp. 8, 131, 133; Burrell, Boston Med. and Surg. Journ., Aug. 8, 1895; Guy's Hospital Reports, Vol. XVII, p. 137, Poland; Wyeth's Essays, p. 168.
"	A lead wire and clamp used at first, then two ligatures; clot firm on cardiac side in innominate; subclavian occluded; carotid open.	Lancet, Dec., 1872; Wyeth's Essays, p. 170; Med. Chir. Trans., Vol. LVI, p. 129.
Death after 20 hours.	. . . .	O'Grady, Power of the Arteries, 3d edition, p. 49; Burrell, Boston Med. and Surg. Journ., Aug. 8, 1895.
Death.	. . . .	Internat. Encyclop. of Surgery, Vol. III, p. 538; British Med. Journ , Vol. II, p. 722.
"	Ulceration on both sides of ligature.	London Lancet, 1866, Vol. I, p. 1064; N. G. Spencer, British Med. Journ., 1889, Vol. II, p. 79.
"	Sac had ruptured in pleura	Wyeth's Essays, p. 168.
Cure.	Section of carotid between two ligatures; strict asepsis.	London Lancet, 1893, Vol. III, p. 327; Med. Press and Circular, March 1, 1893; New York Med. Journ., April 8, 1893; Trans. Acad. Medicine, Dublin, 1893.
Death.	Double catgut.	Quoted by H. L. Burrell in Boston Med. and Surg. Journ., Aug. 8, 1895.
"	Wound had healed by first intention when patient died suddenly on fifteenth day; double ligation of innominate.	Private letter to S. F. Farmento, of New Orleans, La.; also to Walter G. Spencer, Brit. Med. Journ., 1889, Vol. II, p. 79. Detailed and connected account unobtainable in journals
Cure.	Return of aneurism ten years later; collateral circulation through intercostals and subscapular.	American Medical Times, 1864.
Death.	Pulsations returned strong on third day; later, ligation of first portion of subclavian.	British Med. Journ., 1885, Vol. I, p 230; Jacobson's Operations of Surgery, 1889, p. 484; Ballance and Edmunds, op. cit., p. 474.
Cure.	Pressure on common carotid diminished pulsations; tumor was small.	Bulletin de l'Académie de Médecine de Paris, Third Series, 8, 23, 29, January, 1895, p. 97.
Death on eighth day.	Artery ligated below the clavicle; no clot in artery; small opening in artery.	London Med. Gazette, Vol. IV, p. 321; Wyeth, Distal Ligature for Aneurism near Heart, Am. Journ. Med. Sci., 1881, p. 181; Internat. Encyclop. of Surgery, 1883, Vol. III, p. 517; also D. H. Agnew, Principles and Practice of Surgery, 1878, I, 594.
Death.	. . . .	Idem.
"	Was more properly aneurism of first portion.	Idem.
"	. . . .	Idem.
"	. . . .	Butcher's Surgery, 1865, p. 855; Dr. Hayes Agnew, Principles and Practice of Surgery, 1878, Vol. I, p. 594; J. A. Wyeth, loc. cit., p. 181.
Cure.	. . . .	Klinische Wochenschrift, No. 45, Sept., 1891.
Two recoveries.	In one of these cases Rose tied also the carotid and cured the patient.	Ashhurst's Surgery, 1893, p. 62; Rose in Internat. Encyclop. Surgery, Ashhurst, p. 511, Vol. VII, 1883.

DEDUCTIONS—RIGHT IDIOPATHIC ANEURISMS.

Thus, of fifty-six operated cases of idiopathic aneurisms of the right side, eight cases recovered: Syme, Green, Coppinger, Smyth, Monod, Schopf, and two amputations at the shoulder.

Out of forty-nine ligations of all kinds, four recovered (Green, Coppinger, Smyth, Monod).

Out of forty-three proximal ligations, three recovered (Green, Coppinger, Smyth).

In one of these recoveries three arteries were ligated, the innominate, common carotid, and the vertebral (Smyth).

Of eleven proximal ligations of the third portion, one only recovered (Green).

Of six distal ligations of the third portion and of the axillary, with or without simultaneous ligation of the common carotid, only one recovered (Monod).

The dreaded *complications* accountable for such appalling results are as follows:

In twenty-nine of the fifty-six cases hæmorrhage occurred.

In eleven there was sepsis, inflammation, erysipelas.

In one gangrene (Colles, 1813).

In two cerebral symptoms (Pirogoff, Durante).

In one shock (O'Grady).

GENERAL REMARKS.

Here we must make a halt and meditate upon the following most remarkable and impressive facts.

The multiplicity of the operations, the ingenuity, and the boldness of the struggling surgeons deserve more than a passing notice. Their dogged and sublime obstinacy, their undaunted courage in combating this redoubtable disease and their fortitude under defeat, are most wonderful. Baffled at every turn and disheartened for a while they always rise again with the danger and gather new strength in presence of new perils. They always prove equal to them and devise new plans after each signalled failure. The disease is attacked in every conceivable way; one artery after the other is tied, first alone, then two, then three, and even four, increasing the number of ligatures as they are forced to recede. They hoped thereby to render success more probable, but they exhibited at the same time their apprehension, the anxiety in their own hearts. When repulsed by failure on the proximal side they then attack the unrelenting disease on the distal side, but with very little better results.

I.—All the ligatures of the subclavian inside the scalenes, or of the innominate and carotid (in traumatic as well as idiopathic aneurisms), have been almost all followed by lack of closure of the distal end of the subclavian, and by distal hæmorrhage.

II.—It is also remarkable that, although in some cases there was plenty of room for a clot or for occlusion, yet it did not take place.

III.—In the large majority of cases, the length of the right subclavian, from its origin to the point at which it branches, is from one to one and a half inches. (Irwin, cited by Sabine.)

May not abnormal branches account for this?

IV.—Out of two cases of ligature of the innominate, common carotid, and vertebral (Smyth, Durante), secondary hæmorrhage from the vertebral occurred in one (Smyth).

Also in the case of simultaneous ligature of the subclavian, common carotid, and vertebral by Parker.

V.—Lefort thinks that secondary hæmorrhage almost always occurs through the distal end, because the nutrition of the arterial walls of the distal end is inferior to the nutrition of the walls of the proximal end which receives its vasa vasorum directly from the centre, whereas the distal end receives them from the collateral circulation.[98]

According to Lister, the cause of the frequency of distal hæmorrhage is due to the smallness of the clot there; this in turn is due to the fact that it is undisturbed there.[99]

VI.—It is noticeable that Coppinger placed two ligatures on the common carotid and cut the artery between. It is the first time this was done in this region for subclavian aneurism.

VII.—In *résumé;* the ligation of the larger trunks, the innominate and common carotid, has given the best results (Smyth, Coppinger). When the largest and nearest collateral, the vertebral, was also tied the case where it was practised recovered (Smyth); whereas, out of two cases where the innominate and the common carotid alone were ligated (Mott and Coppinger) one only recovered (Coppinger).

TREATMENT IN THE FUTURE.

The efforts of such experimenters as Lister, Wyeth, Senn, Ballance and Edmunds, have established beyond doubt that the proper course for the future is to ligate the artery aseptically with absorbable ligatures without rupturing the coats of the artery. All surgeons are now of the same mind, except Dr. Halsted, who prefers extirpation.

Therefore the following points from the admirable works of Wyeth, of Senn, of Ballance and Edmunds are of special interest and importance, and are set forth here for the benefit of all.

These points concern the vessel, the ligatures, the knot, the clots, the hæmorrhage.

Remarks concerning the Vessel.—The actual thickness of the outer coat of arteries is markedly thin in the subclavian, common carotid, and aorta (B. and E., p. 48). Arteries are very different, in life, from what they are on a fresh cadaver; few recognize the extreme tenuity of the arterial walls under natural circumstances (B. and E., p. 48).

When the tissues are undamaged, the much-dreaded nearness of the collateral branch is immaterial, and even suppuration in the wound is much less serious (B. and E., p. 163).

Diaphragm production is not related to the question of ruptured or intact arterial walls, but must depend upon some fault in the way the ligature is applied or to its too rapid absorption (B. and E., p. 219).

If a temporary ligature be removed at the end of seventy hours, the coats being ruptured, the adventitia will live and the vessel will not be divided (B. and E., p. 224).

To maintain the continuity of the vessel, the coats must not be ruptured and the wound must be aseptic; there is, then, no danger of hæmorrhage, for the vessel is whole and the new tissue forming around it only strengthens it (B. and E., p. 226).

Permanent obliteration of arteries takes place in from four to seven days; in veins from three to four days.[100]

We have removed several inches of the sheath from the carotid of horses before ligating, and have subsequently been unable to observe any difference, either by the naked eye or under the microscope, from those vessels in which the sheath had been left undisturbed. Senn's experience is the same (B. and E., p. 360

If a ligature be applied to a vessel and then immediately removed, the vessel will not, as a rule, be occluded, even if the coats are ruptured (B. and E., p. 366).

If a ligature, such as silk, be applied to an artery so as to rupture the coats and left on the vessel for seventy hours or more and then removed, the vessel will be occluded (Burns, quoted by B. and E., p. 366).

If a ligature be applied to an artery so that the lumen is greatly reduced but not absolutely closed, the vessel will nearly always be occluded (B. and E., p. 367).

The re-establishment of the circulation through the ligatured vessel is much more common nowadays than in the time of silk and rupture (B. and E., p. 437).

Rupture of the coats and septic operations in animals are followed by hæmorrhage as in man (B. and E., p. 15).

From experiments on the lower animals, it is clear that arteries can be permanently occluded without the rupture of any of their coats; to effect this with certainty it is essential to employ a suitable ligature, a suitable knot, tied with appropriate force, and to preserve the strictest asepticity (B. and E., p. 465).

In the case of Mitchell Banks, to be described later, hæmorrhage followed such a ligature of the subclavian; but the artery was thinned and dilated and the ligature applied one-half inch from the sac.

Ligature of the first portion of the right subclavian would be preferable to that of the innominate, for the cerebral circulation would not be materially interfered with (B. and E., p. 474).

If it be desired to ligate simultaneously the common carotid and the first part of the right subclavian, it is easy to reach them both through a single incision passing between the two origins of the sterno-mastoid (B. and E., 476).

It would be advisable first to arrange the ligatures with their knots loosely around the vessels before constricting either; tie the subclavian first; if the carotid be tied first, the pressure on the subclavian would be very high and the force required greater (B. and E., p. 476).

The surgeon should have a fair idea of the amount of force required to effect his object of occluding the vessel without rupturing its coats. He should experiment with human arteries distended with water to the pressure of the blood (B. and E., p. 515).

With this new method, subsidiary questions, such as the amount of clot formed, the presence of atheroma, and the nearness of the ligature to a collateral branch, sink into insignificance when the wall is left alone (B. and E., p. 523).

The degree of the disease, however, is important to consider; when the coats are simply infiltrated and thickened but not rigid and friable, the chances are at their best, but when the arteries are rigid or are more or less calcareous, or if the vessel is dilated or thinned, these conditions are bad (writer).

Concerning the Ligatures.—Senn says he never observed a single case in hospital or private practice where the catgut ligature failed to fulfil in the most satisfactory manner the purposes of a provisional hæmostatic agent until the definitive cicatrix had become sufficiently firm to resist the intra-arterial pressure.[101]

Catgut, Senn says, also appears to constitute itself a part and parcel of the vessel tissues until replaced by substitution, by a ring of organized tissue which serves as a material support to the vessel until cicatrization was completed, thus preserving the continuity of the vessel. All the remaining kinds of ligatures seem to act as foreign bodies, as far as the vessel tissues are concerned, and invariably produce a solution of continuity after a sufficient length of time has elapsed; they are usually found encysted in the mass of connective tissue, between and some distance from the ends of the vessel (B. and E., p. 267).

Senn found that the earliest time in which the loop became absorbed was twenty-one days, the knot alone remaining; after fifty-two days no trace of the ligature could be found (B. and E., p. 270).

By antisepsis alone the great arteries of the body cannot be ligated with absolute safety, as far as hæmorrhage is concerned, but this result may be expected when with asepsis is combined the employment of a suitable ligature so as to occlude the artery without damaging its walls (B. and E., p. 296).

Chromic catgut lasts long enough if no suppuration occurs, but if it does, owing to the cells working into the interstices of the catgut, it becomes rapidly absorbed and is not to be relied upon; this objection does not apply to kangaroo tendon which is absorbed only from the surface (B. and E., p. 377).

Silk and hemp stand boiling in perchloride of mercury solution, in which particular they are superior to catgut and tendon, and can thus be rendered aseptic, and then will not excite suppuration; becoming at first encapsulated and finally absorbed (B. and E., p. 378).

That the ligature may remain quiescent and not cause suppuration, it is necessary that it be aseptic (B. and E., p. 378).

The best method of preserving catgut and tendon (kangaroo) ligatures is in glycerin containing a 1 per cent. of perchloride of mercury; that is a far stronger antiseptic than carbolic oil; in glycerin the ligatures come out pliable and perfectly ready for use, whereas from oil they are stiff and unmanageable and require to be soaked for some time in a watery medium before they become sufficiently soft. Catgut can be kept in glycerin perchloride any length of time, but kangaroo tendon, after two or three months, swells up and softens (B. and E., p. 379).

In both silk and catgut there are fissures and cracks in which bacteria can lodge. Silk can be boiled, but catgut is destroyed by that treatment (B. and E., p. 379).

Wyeth boils the catgut in alcohol and softens it in sterilized warm water (writer).

When catgut is used much care must be given to its preparation. The surgeon cannot control its manufacture, but he is responsible for its asepticity (B. and E., p. 380).

As the outer coat and sheath of the artery consists chiefly of white connective tissue, the most appropriate ligature will be of this material,—*i.e.*, will be either kangaroo tendon or ox-peritoneum ligature; these satisfy all the tests; they are strong, inelastic, round, smooth, pliable, the proper size, slowly absorbable and easily rendered aseptic; of the two, peritoneum is slightly the better, as it lasts longer (B. and E., p. 381).

Boiled floss silk is a smooth and trustworthy ligature.

Failing these, ordinary silk and chromic catgut are good, but their rough surface and the presence in the latter of mucous and muscular tissues are defects. Ox aorta must be rejected on account of its weakness, bulk, and elasticity (B. and E., p. 381).

Senn prefers catgut (writer).

Senn recommends that two ligatures be used, the proximal being tied first. We found it good (B. and E., p. 393).

For the ligation of such large arteries as the innominate, first part of the subclavian, the common carotid, the iliacs, it would be probably advisable to use three ligatures combined into a stay-knot (B. and E., p. 512).

In using two ligatures there is less danger of rupturing the coats (B. and E., p. 445).

With respect to the force used in tying the ligatures, the first hitches of the reef and surgical knots are pulled until an obstruction is felt by the coats coming into contact; at the same time the pulsation in the artery beyond ceases; the knot is then completed (B. and E., p. 464).

The ligature should be made gradually tight until a pulsation is felt below, but none above nor in the aneurism, as the pressure beyond that degree may be dangerous (B. and E., p. 518).

As far as we know, there is no case on record in which a surgeon has ligated with an absorbable ligature one of the arteries usually tied with the intention of not rupturing the coats in which hæmorrhage has occurred (B. and E., p. 469).

The surgeon should hold himself responsible for the asepticity of the operation; also for all the qualities of the ligature, including its strength; the breaking of a ligature is a trying accident (B. and E., p. 515).

Concerning the Knot.—The best knot is the stay-knot (of two ligatures). It is made thus: Make on each separately and the same way the first hitch of a reef-knot (see p. 384), and tighten each separately so that the loop lies in contact with the vessel without constricting it; then taking the two ends on one side together in one hand, and the two ends of the other side in the other hand, constrict the vessel sufficiently to occlude it; finally complete the reef-knot. The simplest method of completing the knot is to treat the two ends in each hand as a single thread, and to tie as if completing a single reef-knot (B. and E., p. 396).

In no case in man has a stay-knot been employed for ligation in continuity (B. and E., p. 469).

In one case of amputation the stay-knot has been used for the femoral, which was much diseased, and all went well (B. and E., p. 469).

Concerning the Clots.—A clot is almost always present above and below when the walls have not been injured (B. and E., p. 145). But it takes no active part in the constructive process by which an artery is obliterated. Senn and all experimenters agree in this; some think these clots are an actual hinderance to the cicatrization, are as much of a foreign body as the clot on the flap of an amputation stump (B. and E., p. 161).

Concerning the Hæmorrhage.—It is probable that, except in those cases in which a large branch is given off just above the ligature, the hæmorrhage more frequently occurs from the distal end than from the proximal (B. and E., p. 293).

In none of the experiments on the lower animals did secondary hæmorrhage occur (B. and E., p. 464).

Conclusions.—To sum up: thorough asepsis, suitable aseptic ligatures (see above), suitable knot, suitable force; the over-denuding of the artery does not matter; nor the presence of a large collateral, nor a *slight* atheromatous condition.

RETROSPECT.

It is most interesting to revert to the past and see the various suggestions which were offered, and are still offered, by operators for the cure of this terrible disease.

(1) Sabine had suggested the simultaneous ligation of the innominate, common carotid, vertebral, also of each branch of the thyroid axis and of the internal mammary. Also of any anomalous branches. In 297 cases the vertebral artery came only seven times nearer than usual to the origin of the subclavian (Sabine).

(2) Markoe had suggested the simultaneous ligature inside and outside the scalenes (Sabine), making sure to be inside the branches (writer).

(3) Wyeth advises to first try the ligature on the distal side, reserving the more dangerous operations on the side nearest the heart as the last resort.[102]

Wyeth recommends the following heroic treatment, remarking that it is not too much so for a ruthless disease. The innominate should be twisted after being tied, the carotid twisted in the same manner, and the subclavian tied near the innominate. All the collateral branches of the subclavian should be tied or twisted. Torsion is recommended especially in cases of wound of the subclavian.[103]

Twisting of the arteries diminishes tension and avoids the great risks of the ligature cutting through as a result of the constant pulsation and pressure brought against it.[104]

Torsion of the subclavian would occlude the vertebral, internal mammary, and the thyroid axis, which would obviate the necessity of their being tied, which should always be done when torsion is not being practised.[105]

If arteries are diseased, torsion would scarcely be safe.[106]

(4) Thompson proposed to ligate the innominate and then to make a longitudinal incision opposite the origin of the subclavian and, through the incision, insert into the artery a round ball of lead or some lighter substance, which we know to become encysted, and await results.[107]

(5) The writer has suggested the simultaneous ligature of the first portion of the subclavian or of the innominate, of the vertebral, and of the axillary above the subscapular; by this means the large avenues of supply are cut off.

(6) In case of threatened rupture of the sac the writer has

also suggested the ligation of the same arteries mentioned above, then opening of the sac; then plugging of the two ends of the subclavian with aseptic fine sponge; securing the other smaller vessels by ligature, or sponge plugging, or by stitching; if necessary the bleeding points should be encircled by an incision, and these small vessels cleared all around sufficiently to ligate them by using or not a curved needle and thread.

The previous permanent ligature of the large trunks is indispensable.

Smyth lost his case upon operating the last time by incision because he opened the sac and attempted to plug without previously securing the axillary, which, in that case, was the only large vessel that had not been tied.

The plugging of the proximal end of the subclavian with aseptic sponge, which may become engrafted, although it is ligated already inside the origin of its collateral branches, would be a possible guarantee against any failure of occlusion of the artery and of its other smaller branches.

It may be said that it is difficult to make sure that the proximal end is really plugged and not an anfractuosity of the sac, but we should plug all the anfractuosities thereabouts with bits of aseptic sponge which will become engrafted.

Deductions as to Treatment.

In conclusion, we will say that strictest asepsis is the sheet-anchor.

The condition of asepsis is so important that all the cases of the pre-aseptic period ought to be left out in all statistics or comparisons.

Next to this, the best plan to pursue in the future is:

Ligate the first portion of the subclavian with a double, or better triple, non-contiguous, absorbable ligature without rupturing the coats (writer).

Senn was the first to recommend double ligation on the continuity of an artery.

He relies on the *bloodless space* between the ligatures for obtaining prompt and early obliteration of the lumen of the vessel. Also after amputations, as a rule, resting his advice on the experimental basis.

Senn's idea of applying double *non-contiguous* ligatures is truly most happy, important, and decisive, inspiring, as it does, a deep sense of security that never existed before.

It is preferable to ligate the first portion of the subclavian rather than the innominate, for the cerebral circulation would not be interfered with.[108a]

We should bear in mind Twyman's statement, that cerebral symptoms occurred three times in twenty-two cases,—*i.e.*, about 17 per cent.[108b]

When it is decided to ligate the subclavian and the common carotid simultaneously, it is best to ligate first the subclavian; otherwise the impulse against the subclavian would be much increased and might prevent the proper tightening of the ligature (B. and E., p. 476).

It would be safer to ligate the vertebral in like manner at the same sitting.

If that is not done, and if pulsations continue or return, it must be done.

We advise the above course because we do not believe that an artery can regain its patency after it has been so effectually obliterated by a double or triple catgut ligature tightened so as not to rupture the coats, but enough to stop all pulsations in the aneurism and the large efferent artery.

In the case of Mitchell Banks, to be related further, this repatency occurred, but it was because a single ligature had been applied, and on such a large vessel as the innominate.

In some of the successful ligatures, silk was used, and in most of them the coats were likely ruptured, yet the same occlusion can be obtained with as much certainty and less risk with absorbable ligatures when used *double* and especially *non-contiguous*,—*i.e.*, with a bloodless space between the two.

In some unsuccessful cases absorbable ligatures were used, but they were used singly.

It is especially when the vessel is found much enlarged and somewhat thinned that the double ligature is called for imperatively.

As regards the *choice of the operation,* we unhesitatingly advocate the resection of the inner extremity of the clavicle and of the adjoining part of the sternum. It is of the utmost importance that the ligations should be deliberately, systematically, and thoroughly done, and everything has to be sacrificed to that end, upon which depends the supreme aim itself. The recent case of Dr. H. L. Burrell is quite in point. Cooper, of San Francisco, had preceded him in 1859. Bardenheuer, who has repeatedly exposed the innominate and its branches by such an operation for removing tumors involving the root of the neck, says that those points can only be carried out by such resections of those bones.[108c]

We should also not lose sight of the fact that in idiopathic aneurisms, the *general condition of the patient* is defective, and, if time allows, before operating proper care should be taken to have him in as good general condition as possible. Whatever peculiar diathesis may exist in him should be properly counteracted, and his blood made as rich and plastic as possible, by careful diet, thorough rest, and proper medication.

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